

Muons in action – the muon spin rotation station at the Swiss Paul Scherrer Institute.

er short-lived. This is potentially a valuable source of neutral kaons.

Current designs for phi factories fall into two classes – compact machines with superconducting elements (e.g. Novosibirsk and UCLA) and larger conventional rings (Frascati, KEK, Mainz). Synchrotron damping time is shorter in the former at the expense of more complicated filling procedures. Room-size compact machines could also be considered as candidates for compact synchrotron light sources or for other types of particle factory. However the detectors for use at these compact rings would not be correspondingly scaled down.

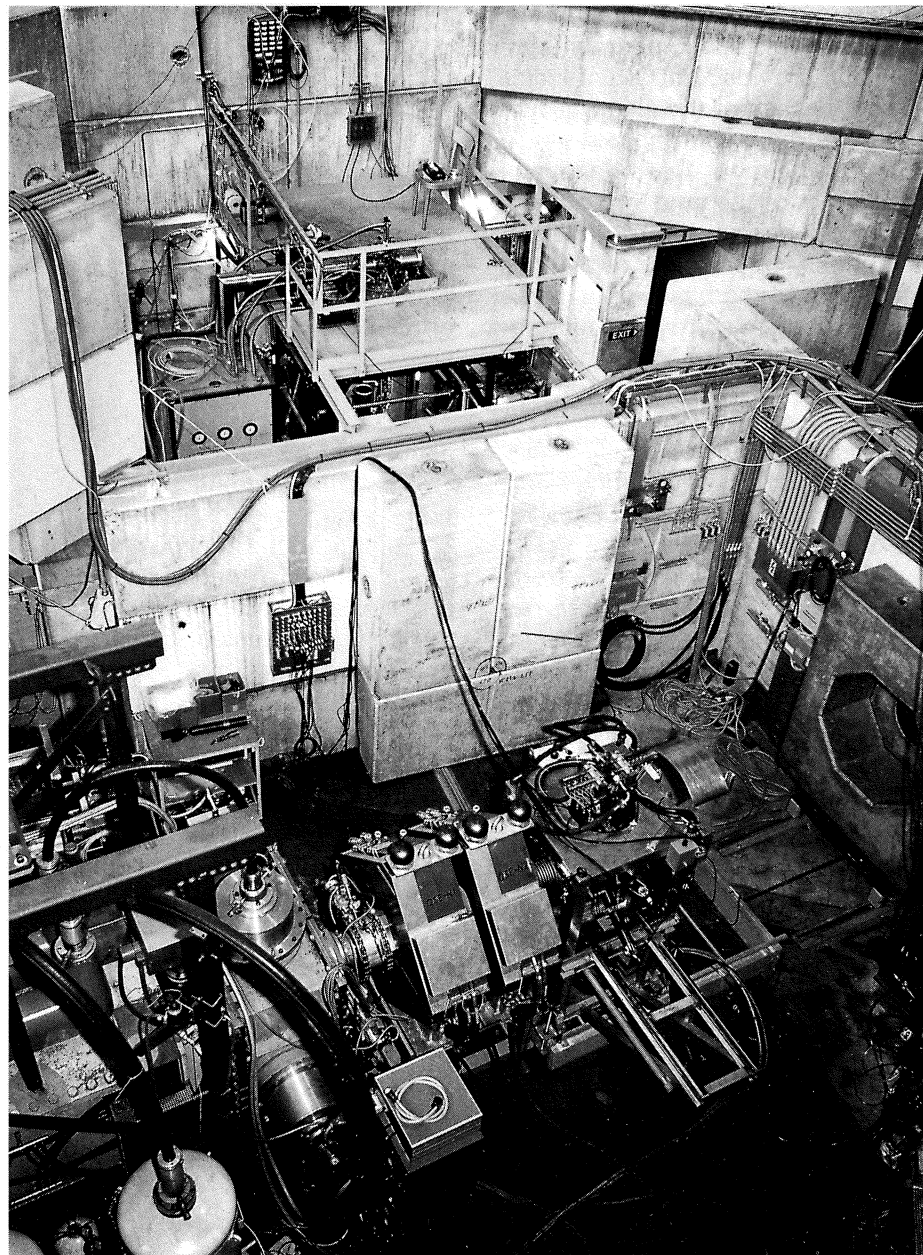
Luminosity should reach 10^{33} per sq cm per s, providing some 10^{10} phis per year decaying into neutral kaons and opening up a useful range of physics. At the UCLA meeting, detector and machine specialists felt that the special requirements of a phi factory were within reach.

Musing over muons

The Standard Model of modern physics looks simple – six types of quark grouped pairwise into three families, each associated with a different type of weakly interacting particle, or lepton – the electron, the muon and the tau.

Despite its many successes, this picture cannot be the end of the road. Why is the muon about two hundred times heavier than the electron? The answer is hidden by the Standard Model's price tag.

The physicists attending a workshop on Low Energy Muon Science in the 1990s, held at the Swiss Paul Scherrer Institute (PSI) in April, were looking for ways to learn



more about the muon and uncover what lies behind the Standard Model.

Experiments searching for new muon decay modes probe down to one decay per hundred million and in some cases even much less, but even this close no cracks show up in the Standard Model facade. Convinced there has to be a deeper

message, the physicists prepare for new rounds of experiments to subject the model to even closer scrutiny.

A related issue is the masses of the three neutrinos which accompany the trio of leptons. Again there are as yet no theoretical guidelines, but neutrino masses play an important role in basic pro-

People and things

cesses, such as those of interest to astrophysicists. Experiments at PSI have provided important limits on the masses of the electron-type and muon-type neutrinos.

When the muon does decay, it goes most of the time into an electron and a pair of suitably labelled neutrinos. The strength of this decay is one of the basic input parameters of the electroweak picture within the Standard Model. Careful analysis of the spins of the muon and the electron in these decays, together with studies of the scattering of muon-type neutrinos off electrons, could help look beyond the Standard Model.

Other insights could come from tiny violations of basic symmetries (mirror reflection, time reversal) in muonic atoms and in muon capture by nuclei. These and other muon studies are now so sensitive that any positive effects would signal mechanisms comparable to those produced by particles with masses around 15 TeV (15,000 GeV), heavier than anything discovered so far and heavy even by the standards of the giant proton colliders of tomorrow.

Another theme at the meeting was nuclear muon capture, when an orbital atomic muon disappears into the nucleus, giving a muon neutrino and possibly an excited nuclear state. (Because the muon is so heavy, muonic atoms are much more compact than their electronic counterparts and nuclear interactions correspondingly more important.) Pooling together information from several sectors, experimental tools are now emerging for the systematic exploitation of nuclear muon capture as a probe of nuclear structure and weak nuclear interactions.

When the nucleus is just a single proton, muon capture can help ex-

plore the low energy regime of quantum chromodynamics (QCD), the candidate field theory of quark interactions and, with the electroweak picture, one of the twin facets of Standard Model formalism. Muon capture on hydrogen has been a challenge to experimentalists; the process is rare and is masked by atomic and molecular effects, but a new generation of studies is planned at meson factories.

Atomic and molecular physics again emerges as a dominant theme in the interaction of muons with hydrogen isotopes – deuterium and tritium. Compact muonic atoms have long been advocated as a possible catalyst for controlled thermonuclear fusion, but the various possible paths are difficult to calculate theoretically and unravel experimentally. Low energy muons slowed down by a layer of frozen deuterium are currently being looked at, and the discovery last year of muonic deuterium by stopping muons in a layer of frozen hydrogen with a small concentration of deuterium provides a new ingredient.

One sector which has really taken off is muon spin rotation – the electron from muon decay points to the spin direction of the muon, itself a gauge of the local electromagnetic fields. With this technique, custom-built muon beams provide a precision tool for condensed matter physics, a good example being recent investigations of the structure of the new generation of high temperature superconductors. New sources of low energy beams would benefit surface physics.

For a particle not yet understood, the muon is pretty useful.

From Jack Missimer, PSI

20 Tesla for sale

An Oxford Instruments superconducting solenoid magnet which has exceeded 20 Tesla is now available commercially. Although higher fields have been achieved with laboratory magnets, this is said to be the most powerful such magnet on the market.

Operating at 2.15 K, the 32 mm diameter coil uses niobium-titanium wire for the outer windings with the inner sections of niobium-tin optimized for high field use. Oxford Instruments is at Eynsham, Oxford, OX8 1TL, UK, telephone (+44)865 882855, fax (+44)865 881567.

Boost for Dubna

To provide a foundation for future physics at the Joint Institute for Nuclear Research (JINR), at Dubna, near Moscow, an international commission recently pledged their support for a new electron-positron storage ring to extend the centre's physics activities. As well as synchrotron radiation-based studies, such a machine would open up the physics of charm particles and tau leptons. An ion option for the ring is also foreseen.

The physics programme of the 11 Member State JINR Organization has so far centred on its 10 GeV Synchrophasotron, operational since 1957.